

A Comprehensive Simulation-Based Framework for Design of Army Ground Vehicles

G.M. Hulbert, Z.-D. Ma, Y. Hahn, G. Ryu

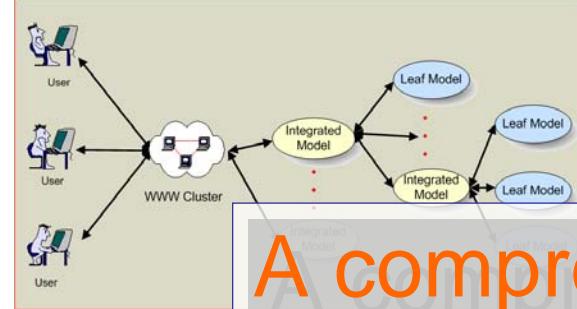
2007 SAE World Conference

April 16, 2007



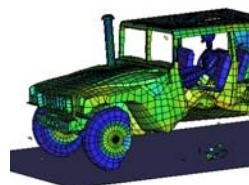
Report Documentation Page			Form Approved OMB No. 0704-0188					
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Presentation Overview

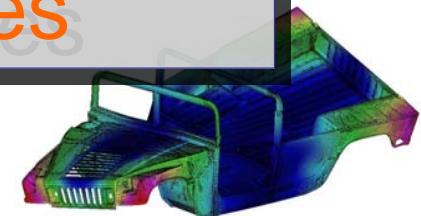
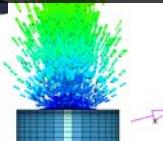


Distributed
& Design

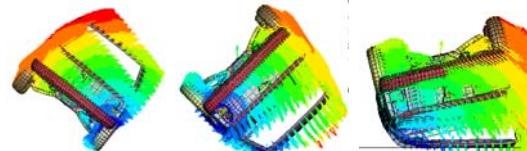
A comprehensive framework for
supporting analysis and design of
Army's current and next
generations of tactical vehicles



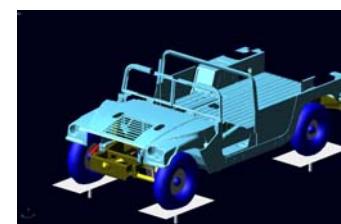
Blast



Durability and Ride



Crash

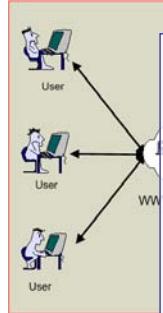


Rollover

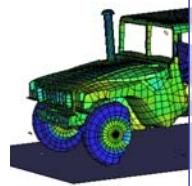


Presentation Overview

- Working capability for distributed simulation across multiple domains
- New modeling capability for rapid configuration of HMMWV variants
- New modeling techniques for accurate, efficient simulation and design

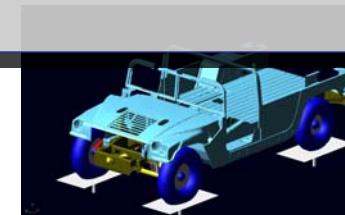
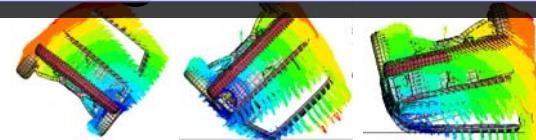


Distributed
& Design

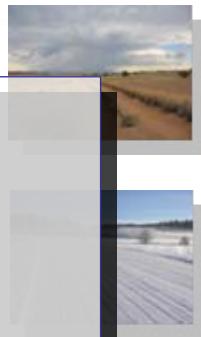


Blast

Crash



Rollover



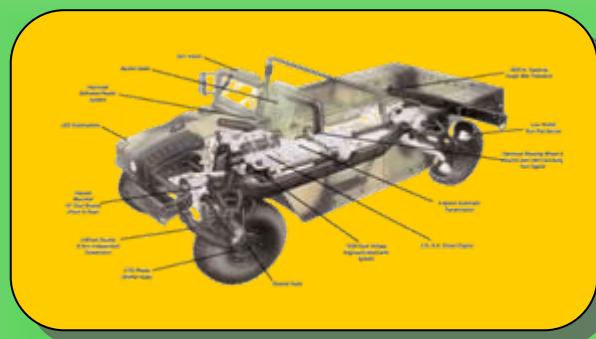
Ride

Research Objectives

- Develop an integrated simulation and design capability to support:
 - Modularized product development of current and future vehicle families



The HMMWV Family

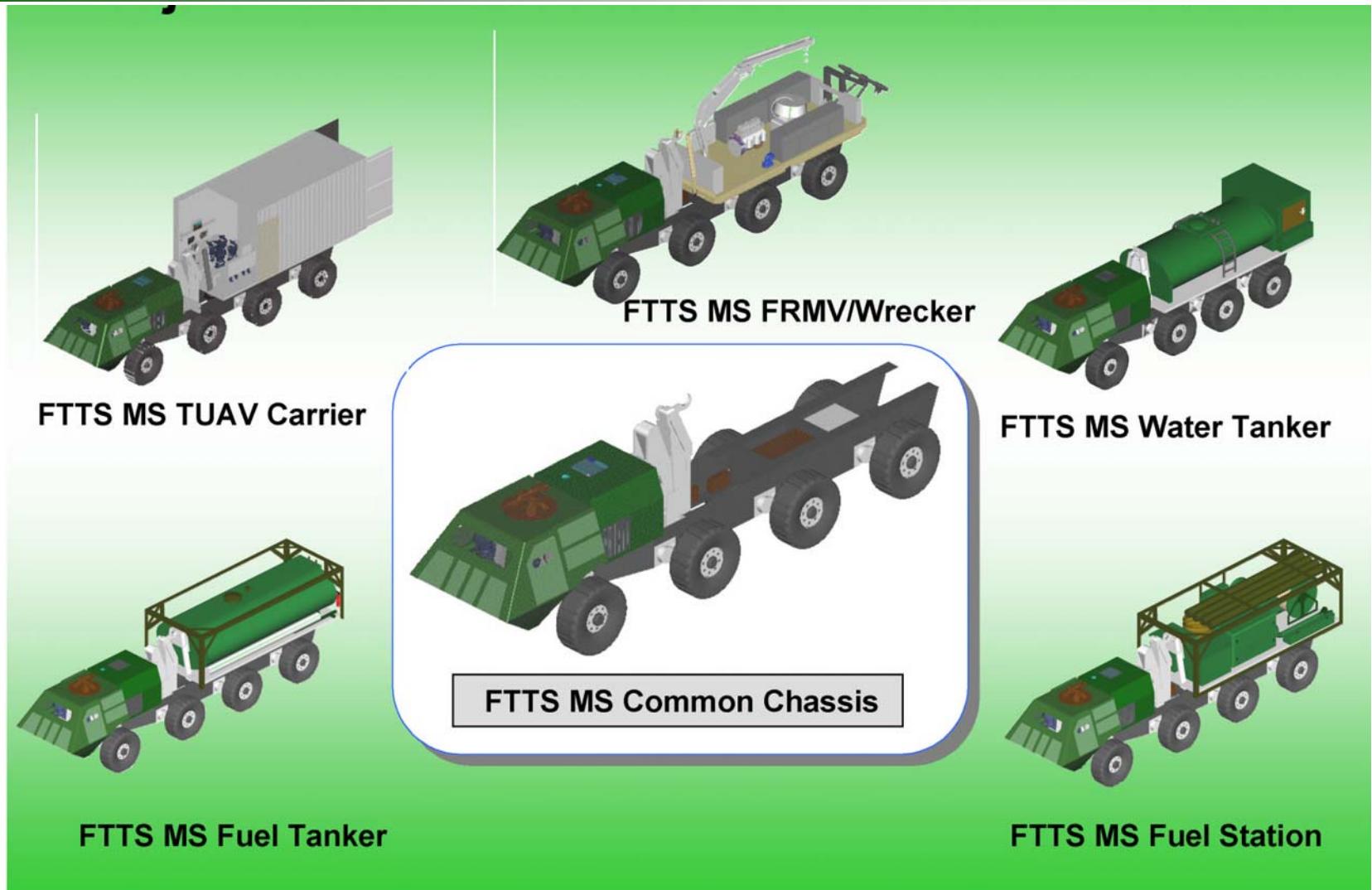


Research Objectives

- Develop an integrated simulation and design capability to support:
 - Modularized product development of current and future vehicle families
 - Innovative vehicle concepts in support of Army transformation



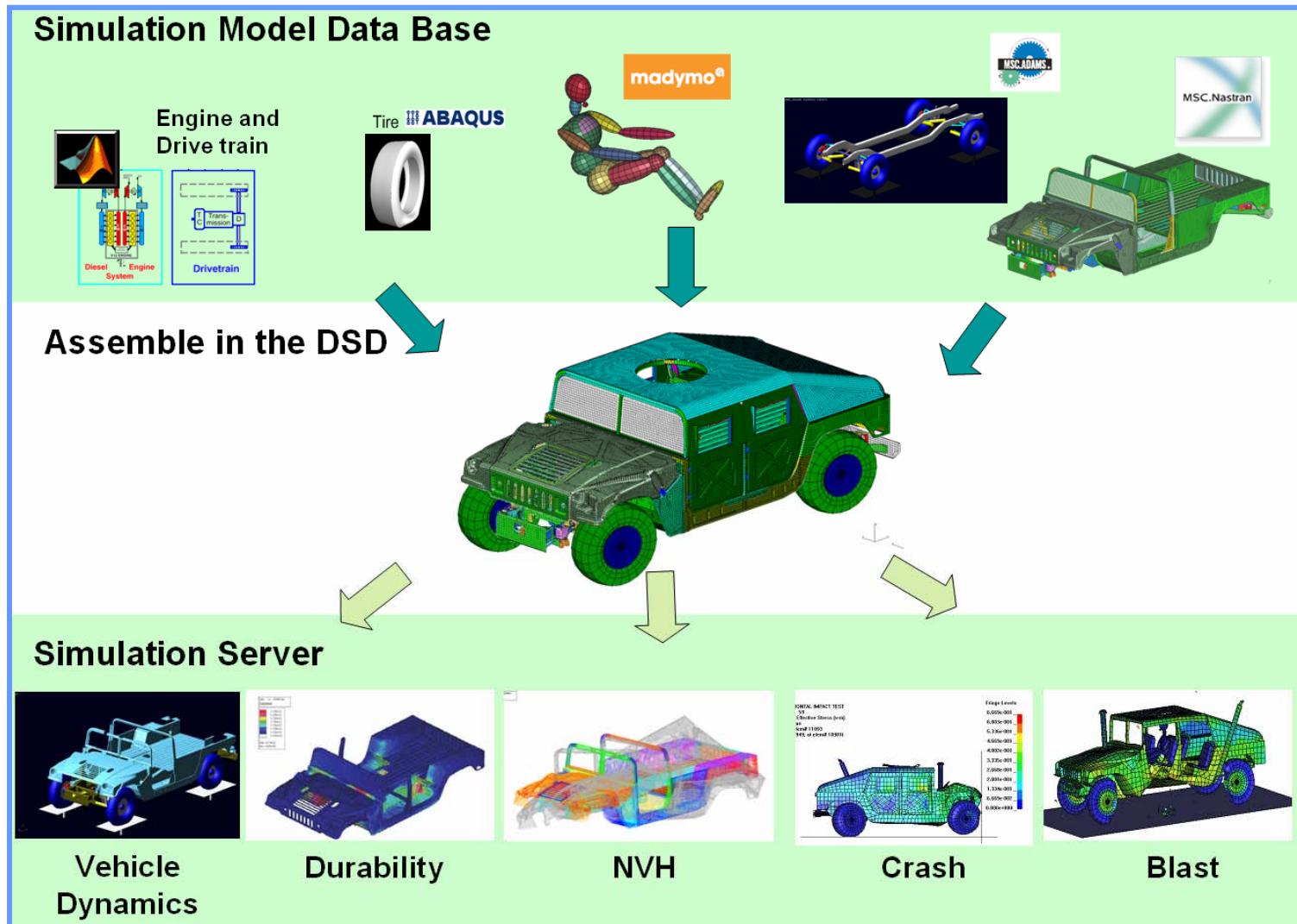
Future Tactical Truck System



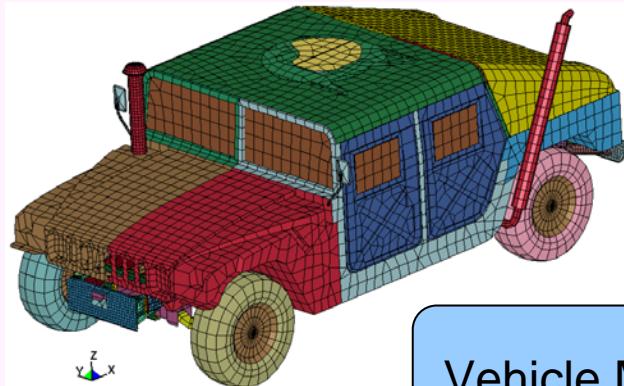
Research Objectives

- Develop an integrated simulation and design capability to support:
 - Modularized product development of current and future vehicle families
 - Innovative vehicle concepts in support of Army transformation
 - Efficient integration of distributed models, simulation codes, and new design methodologies for commercial and military applications

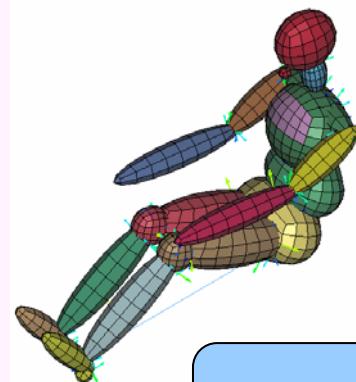
Vision of Distributed Simulation and Design



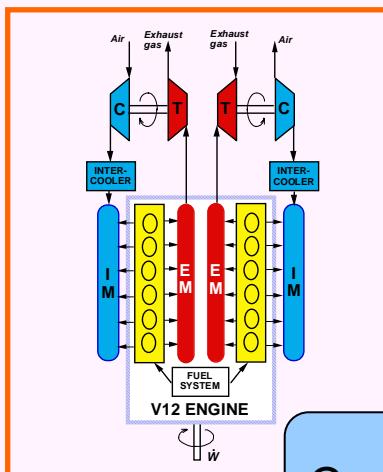
Requirement: Multi-Domain Simulation



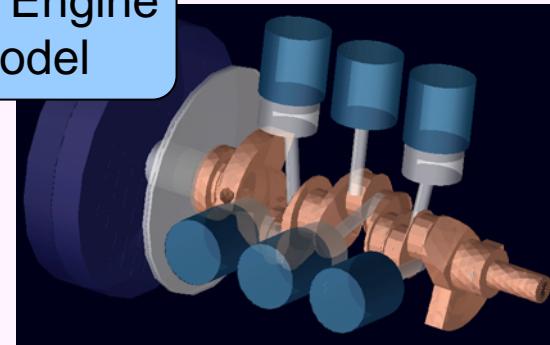
Vehicle Model



Human Model

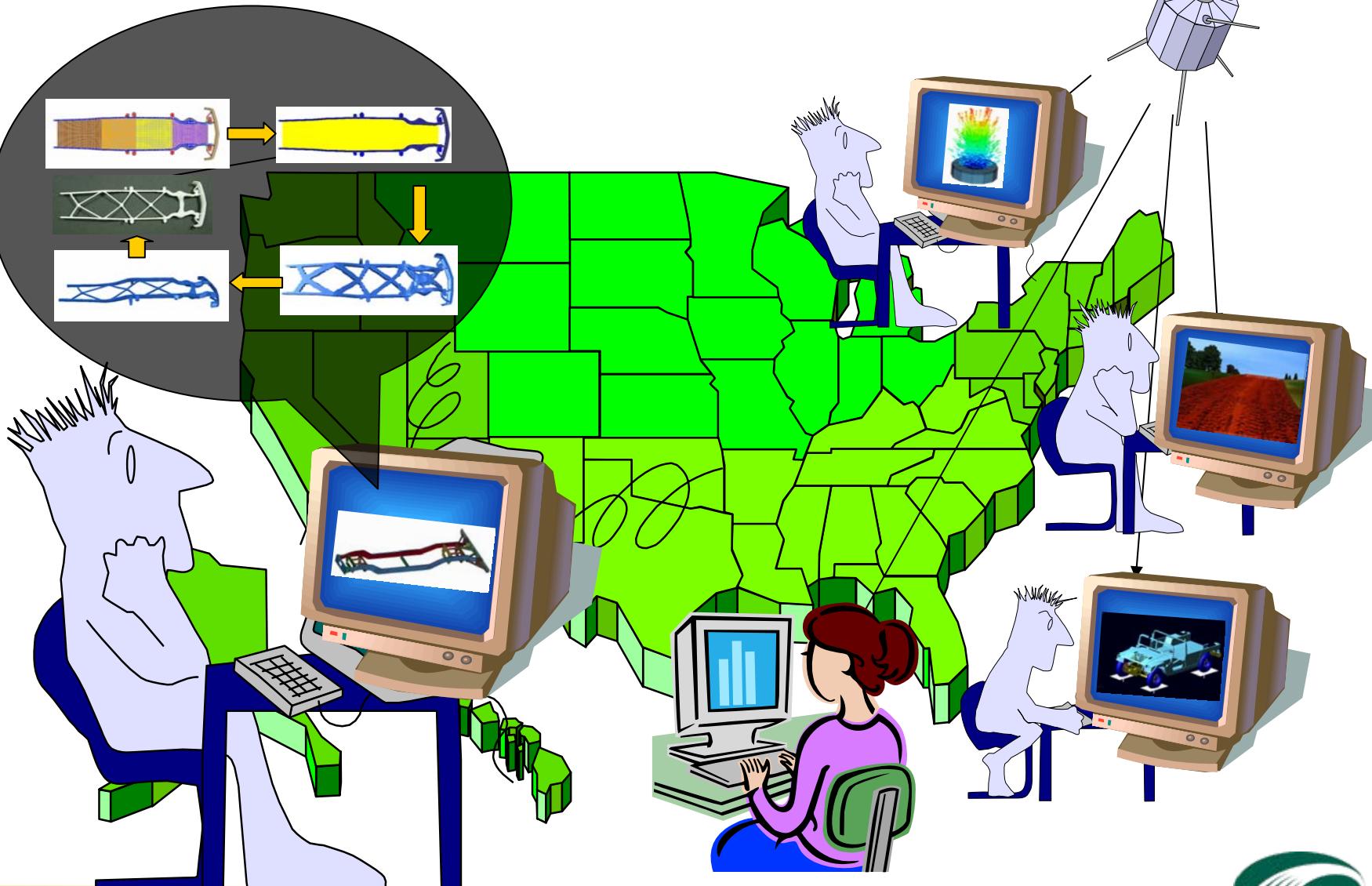


MBD Engine Model

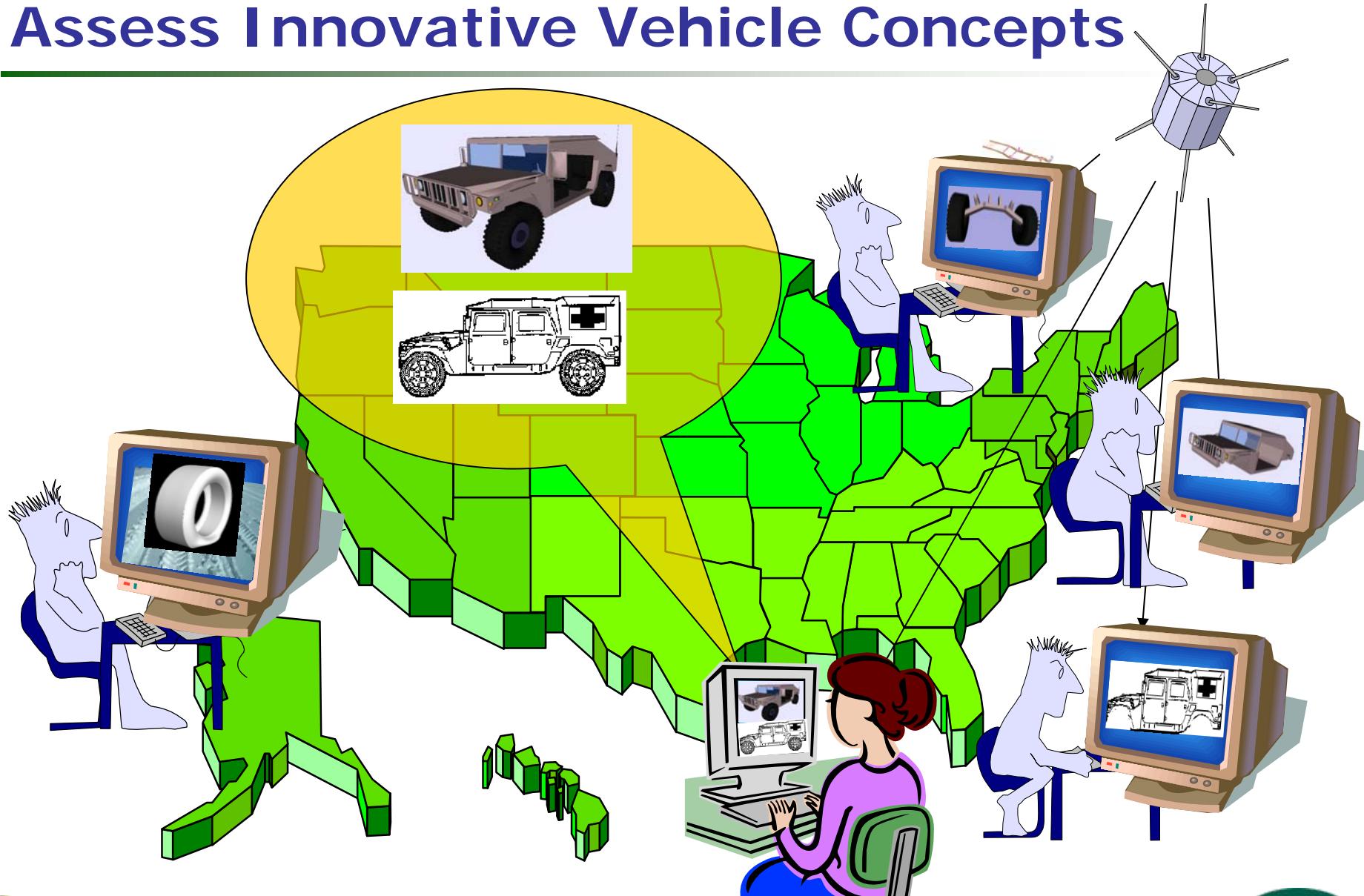


Combustion Model

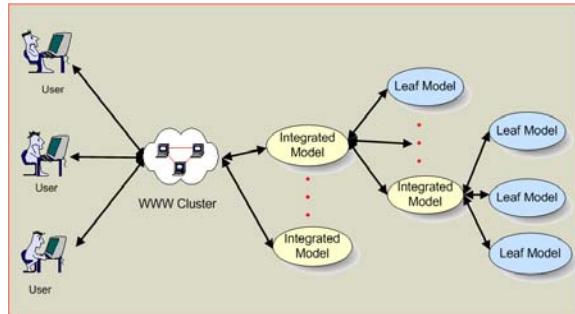
Requirement: Subsystem Design Embedded in Hierarchy of Systems



Requirement: Rapid Configuration to Assess Innovative Vehicle Concepts

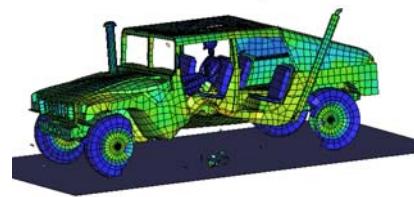
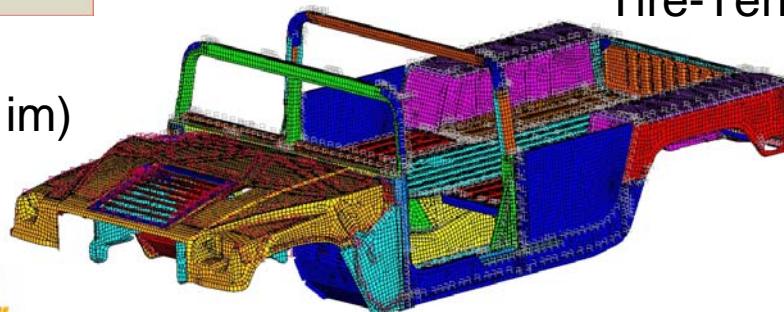


Overview

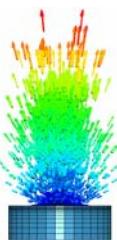


Tire-Terrain Interaction

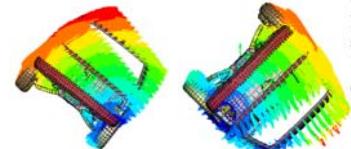
im)



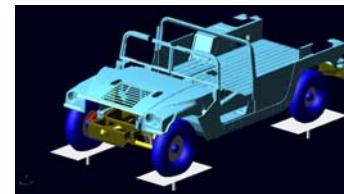
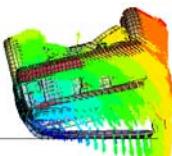
Blast



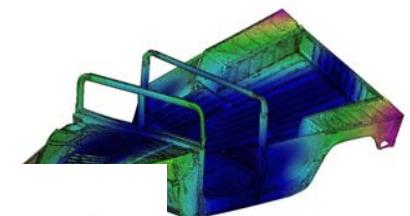
**Distributed Simulation
& Design Platform (D-Sim)**



Crash



Rollover

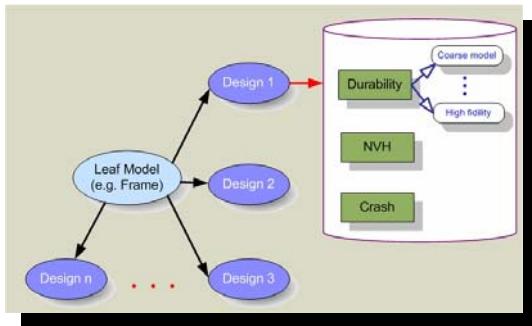


Durability and Ride

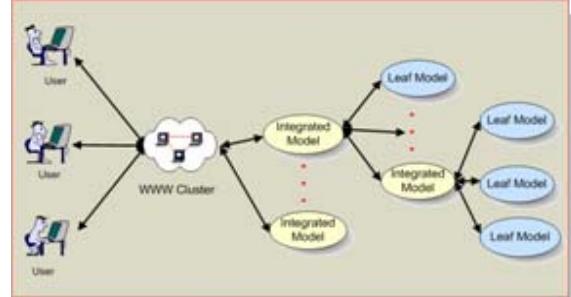


Major Components of D-Sim

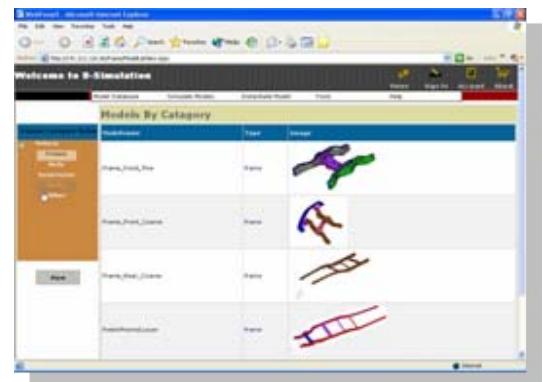
Model Database



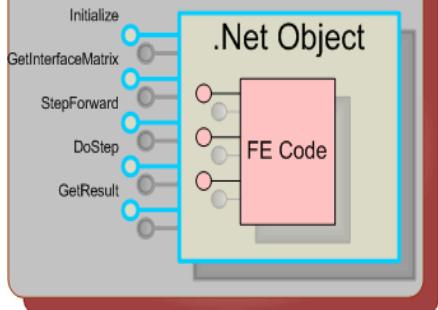
Distributed Architecture



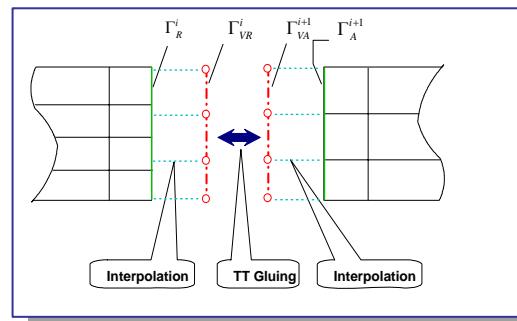
Web-based Interface



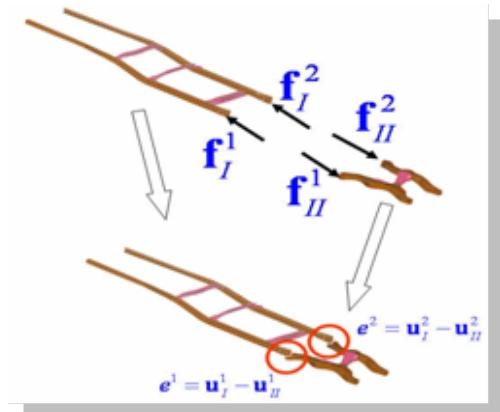
Component Model Server



Simulation Code Wrapper



Non-matching Interfaces



Gluing Algorithm

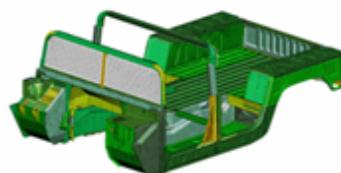


Collection of HMMWV Subsystem Models



Integrated Systems Approach

Hood Assembly
(Leaf Model)

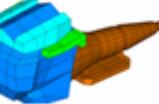


Upper body
(Integrated Model)

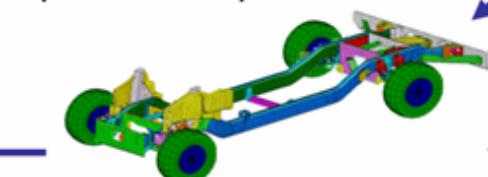


M1097A2

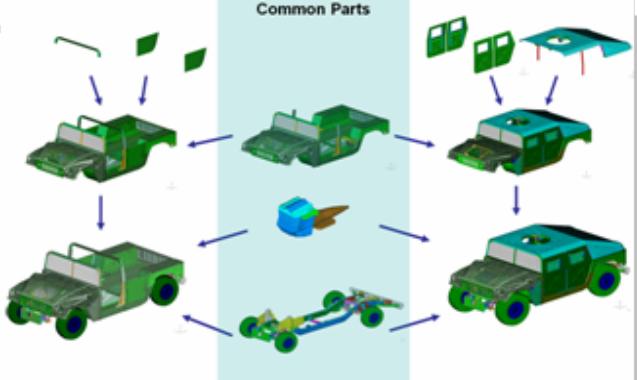
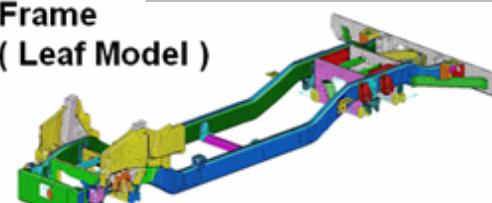
Power Train
(Leaf Model)



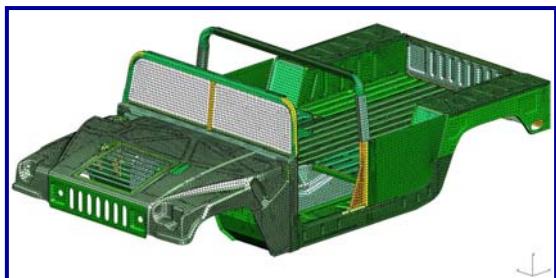
Chassis System
(Integrated Model)



Frame
(Leaf Model)

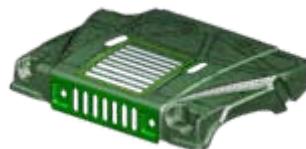


Rapid Configuration of Different Vehicles

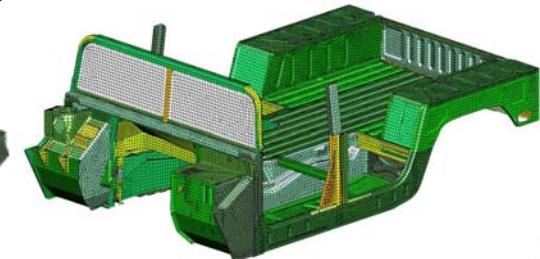


M1097A2 UPPER BODY

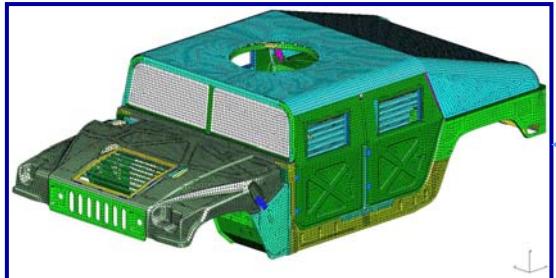
Common Parts



HOOD ASSEMBLY



HMMWV BASE UPPER BODY



M1025 UPPER BODY



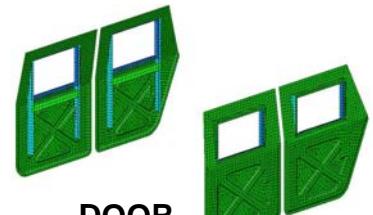
B-PILLAR
CROSS MEMBER



RR DOOR



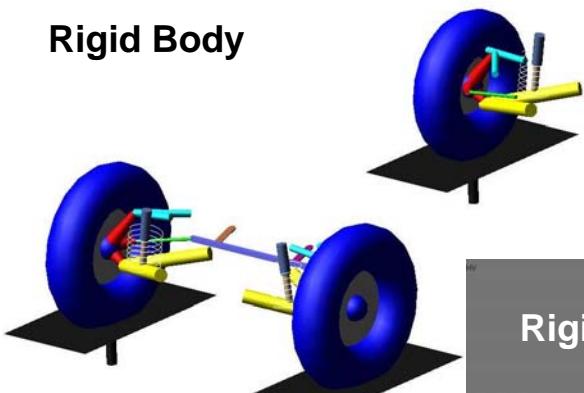
ROOF ASSEMBLY



DOOR
ASSEMBLY

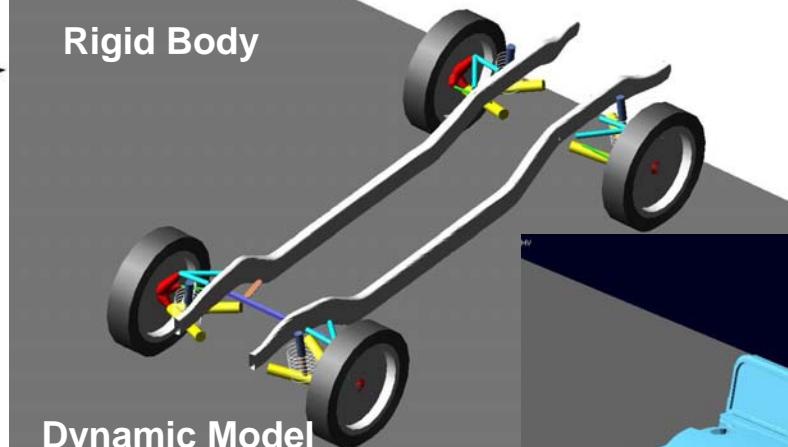
Rapid Substitution of Different Fidelity Models

Rigid Body



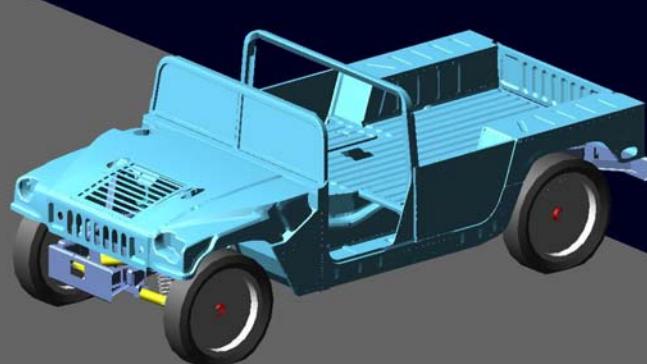
Static Model

Rigid Body



Dynamic Model

Dynamic Model

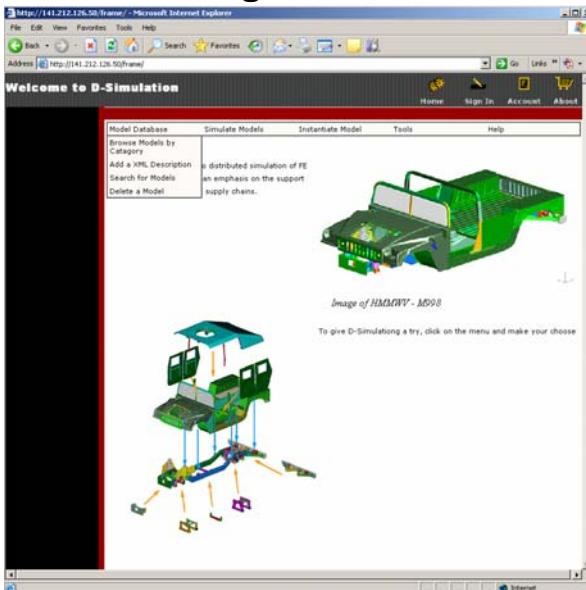


Flexible Body



Web-Based Interface

Main Web Page for D-Simulation



UPPER BODY PARTS

A screenshot of a Microsoft Internet Explorer browser window titled 'ModelSearch - Microsoft Internet Explorer'. The main content area is titled 'Welcome to D-Simulation'. It shows a search results table for 'UPPER BODY PARTS'. The table has columns for 'Model Name', 'Category', 'Description', and 'Model Image'. The results are as follows:

Model Name	Category	Description	Model Image
M1097A2 MAIN BODY ASSEMBLY	body	HMMWV FRAME FRONT ASSEMBLY	
HMMWV HOOD ASSEMBLY	body	HMMWV FRAME FRONT ASSEMBLY	
M1097A2_BODY	body	HMMWV M998. UPPER BODY Part	
FRAME_UPBODY_ASSY	body	Integrated HMMWV M998 FRAME AND BODY ASSEMBLY	
UP_BODY_MAIN	body	MAIN UPPER BODY OF HMMWV M102S MODEL	
ROOF_ASSY	body	ROOF ASSEMBLY OF HMMWV M102S MODEL	
DOOR_ASSY	body	ROOF ASSEMBLY OF HMMWV M102S MODEL	
UP_BODY_ROOF_DOOR_ASSY	body	UPPER BODY PARTS INTEGRATED MODEL OF HMMWV M102S	

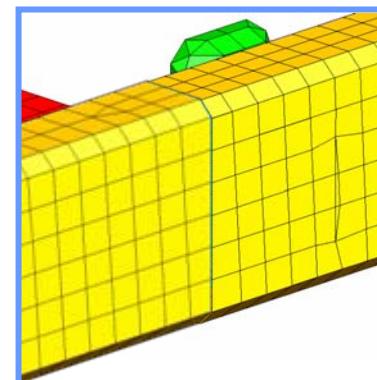
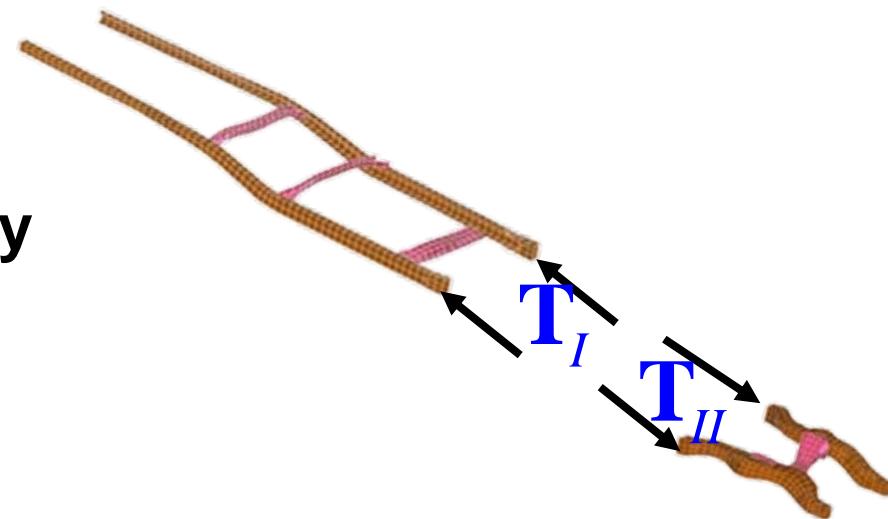
On the right side of the interface, there are several smaller windows or tabs showing different 3D models and simulation results, including a green car model and a red and blue simulation visualization.

ARTS

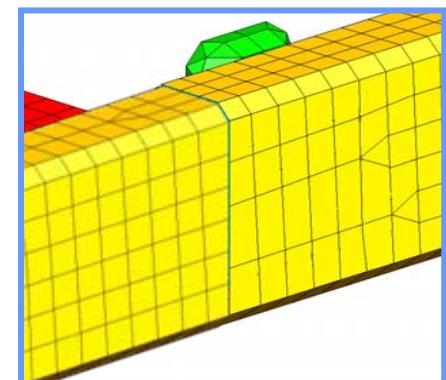
- Search multi-layered model database
- Define interfaces for model integration
- Generate new distributed simulation and design models

Gluing Algorithm and Non-Matching Interfaces

- Enables multi-platform, multi-layered plug and play capability
- Standardizes model interfacing
- Protects proprietary data / models

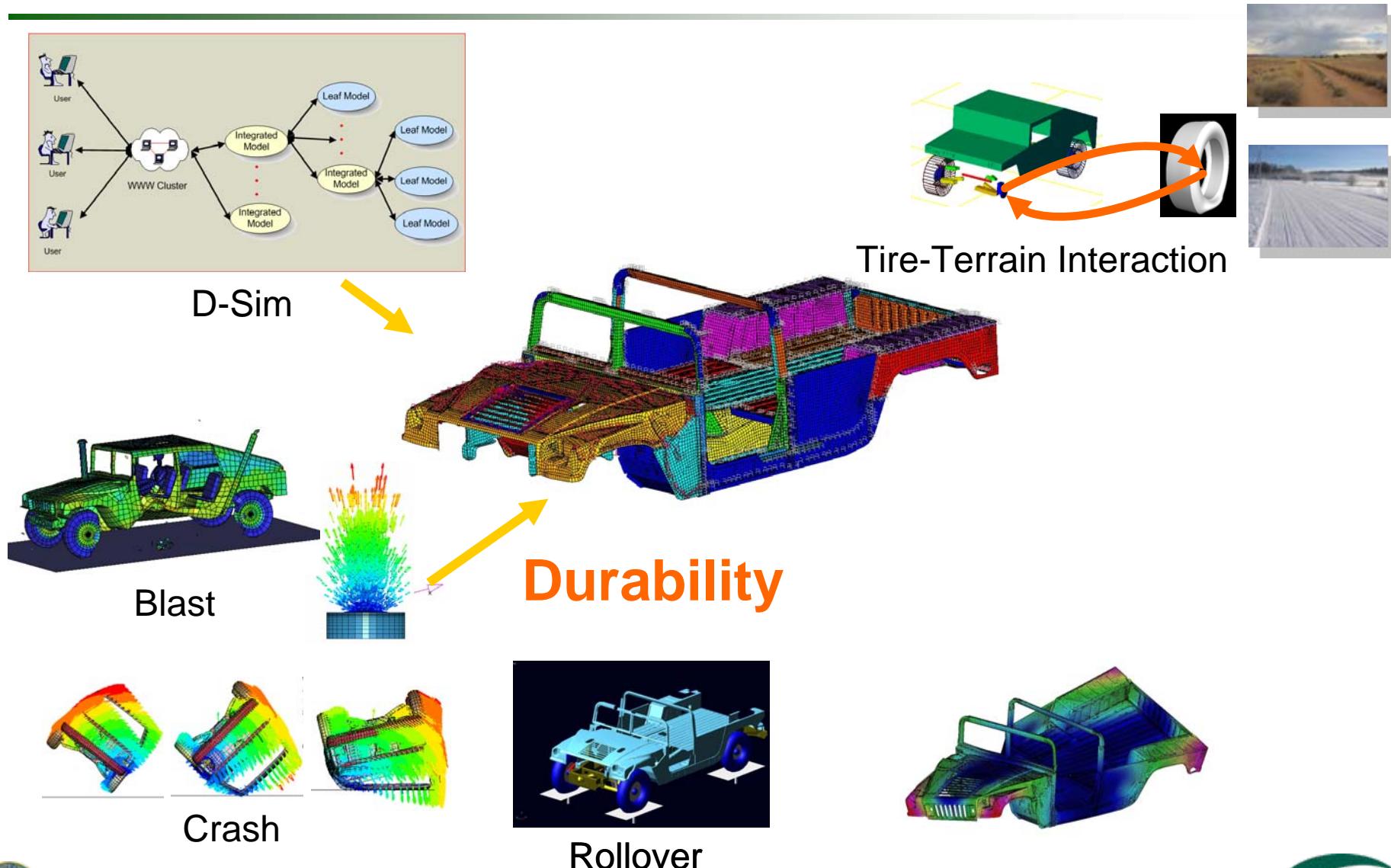


Matching



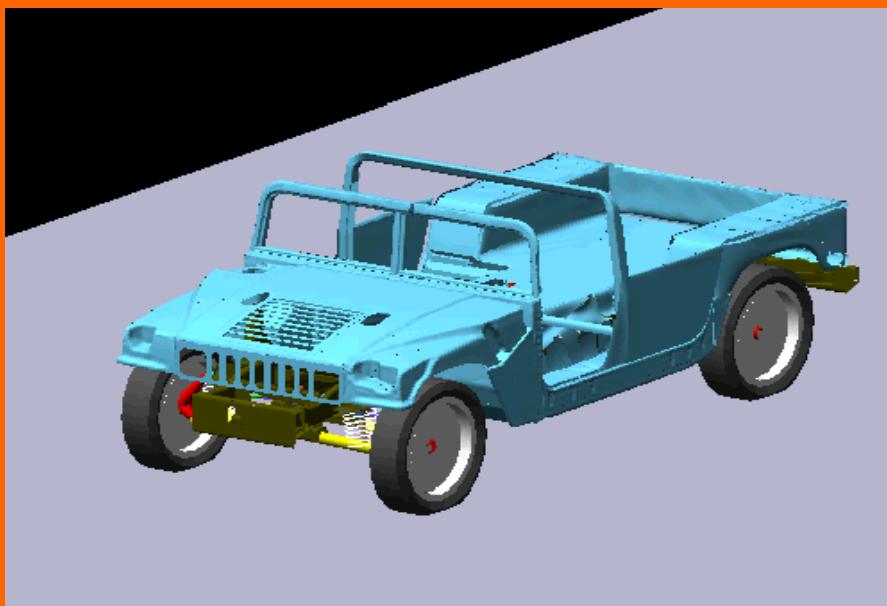
Non-Matching

Overview

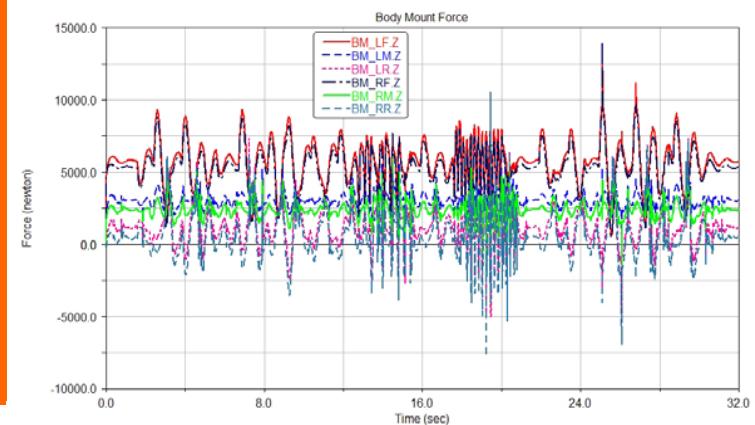


Durability Road Simulation

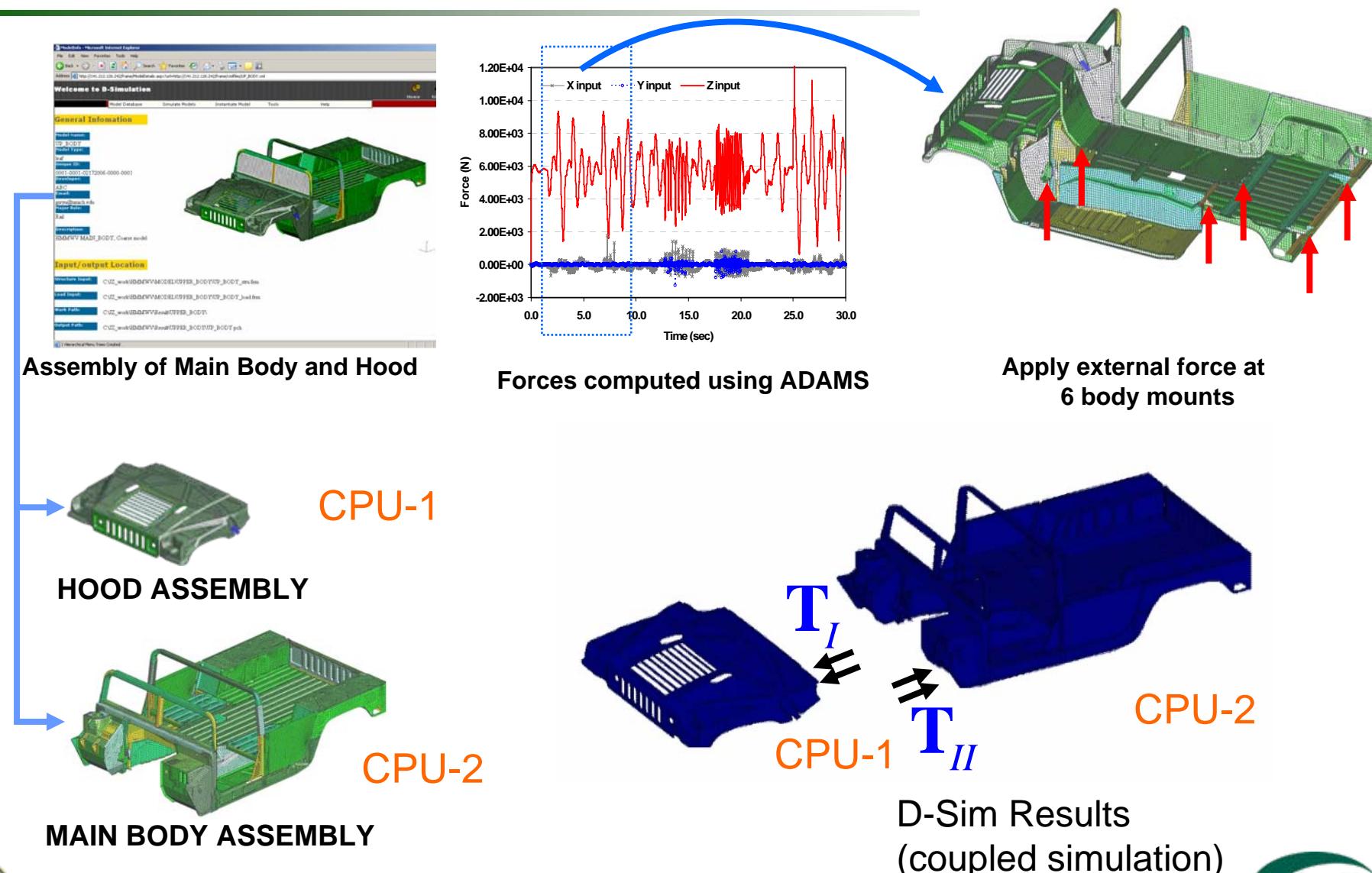
Durability Road



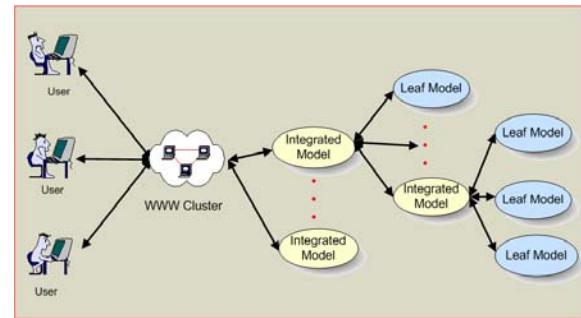
Computed Body Mount Forces



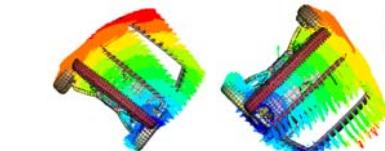
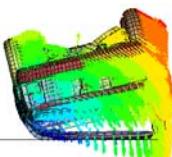
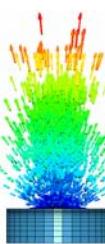
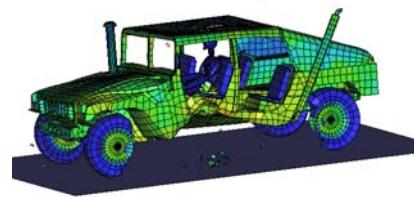
Gluing Algorithm for Durability



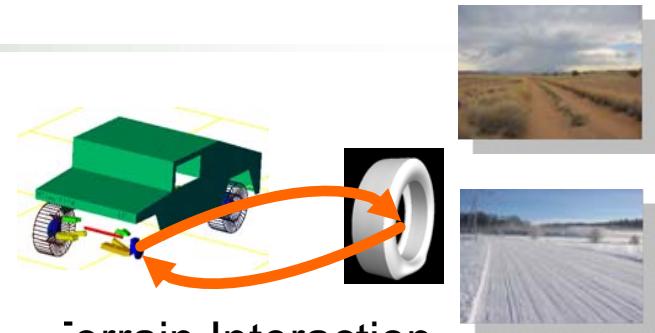
Overview



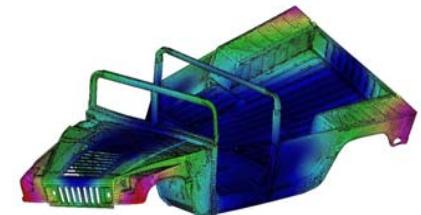
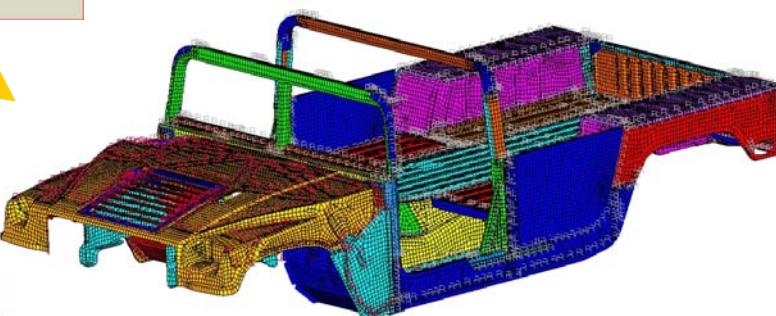
D-Sim



Safety



Terrain Interaction



Durability and Ride

Safety Applications



Rollover



Crash



Blast



Extreme Terrain

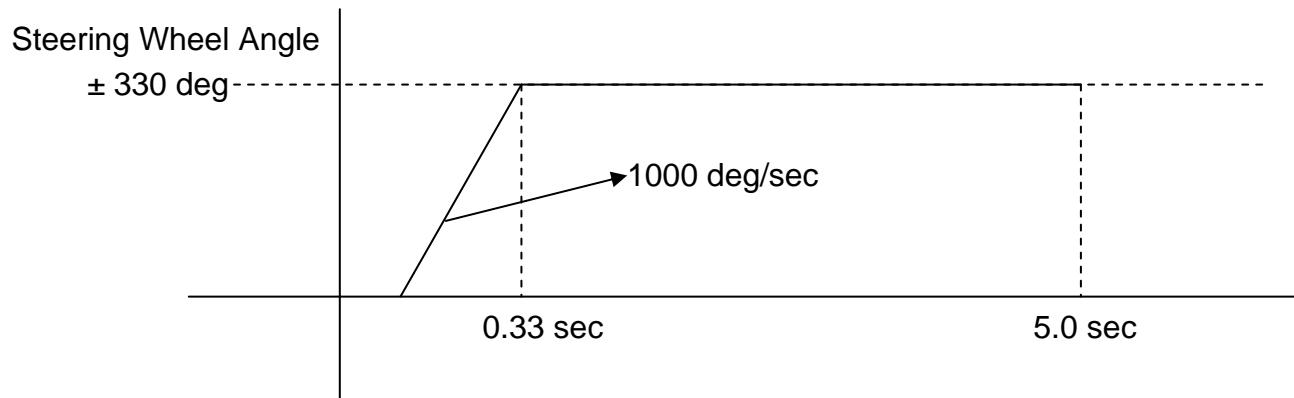
HMMWV Rollover



J-Turn Rollover Simulation (Flat Ground)

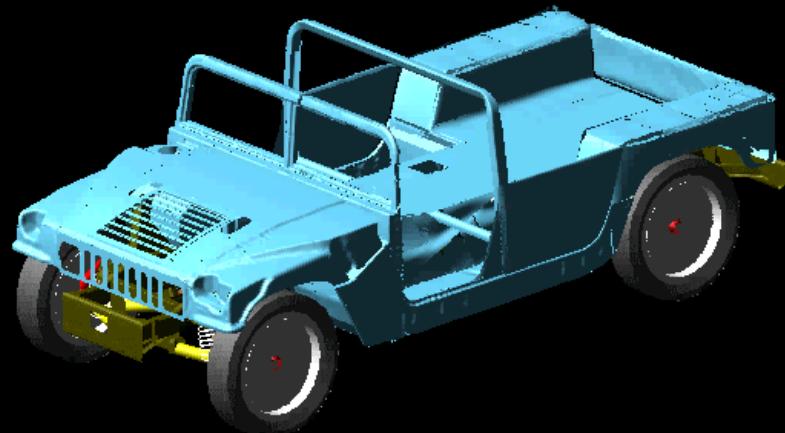
Driving Conditions

- Modified test protocol
- Initially driven in a straight line
- Initial speed: 10 mph and up
- Test runs for 5 seconds



J-Turn (Rigid Body Model)

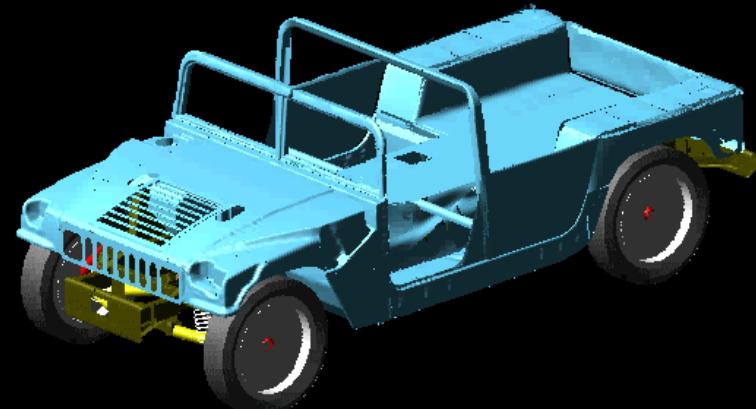
Time= 6.0000 Frame=001



- Predict critical speed range
- Study rollover behavior
- Assess effect of up-armor system
- Design for rollover prevention

Time= 6.0000 Frame=001

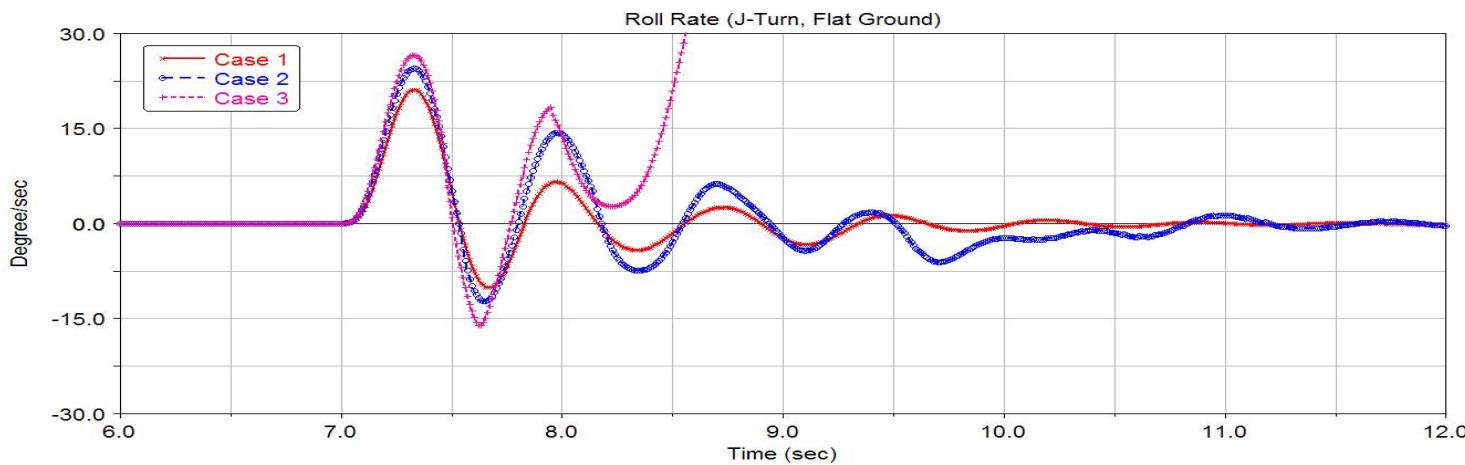
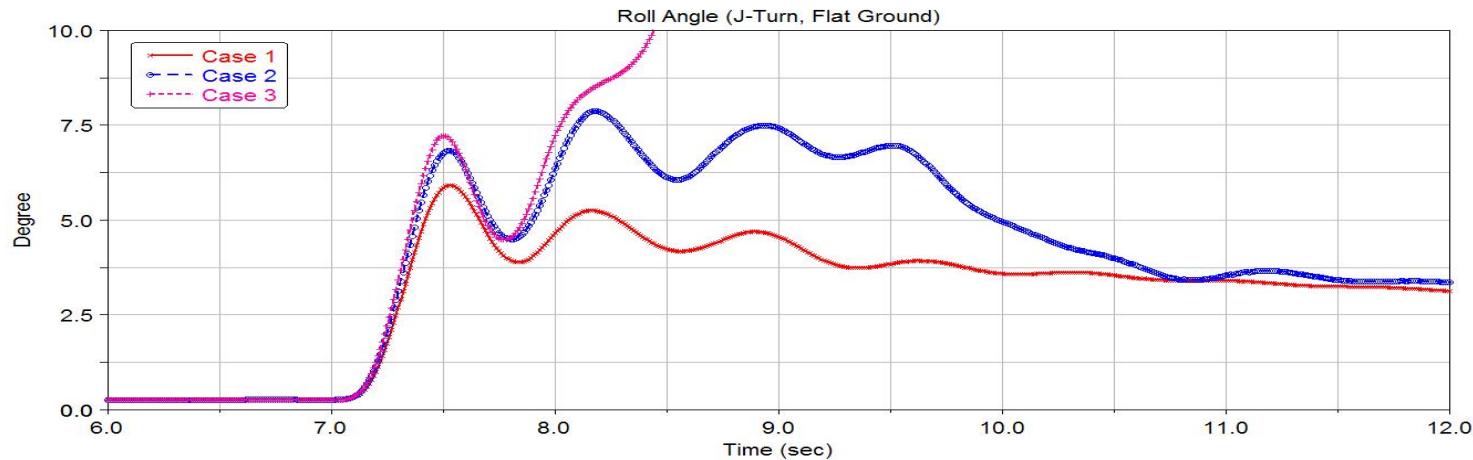
Nominal speed



Nominal speed+ 10 mph

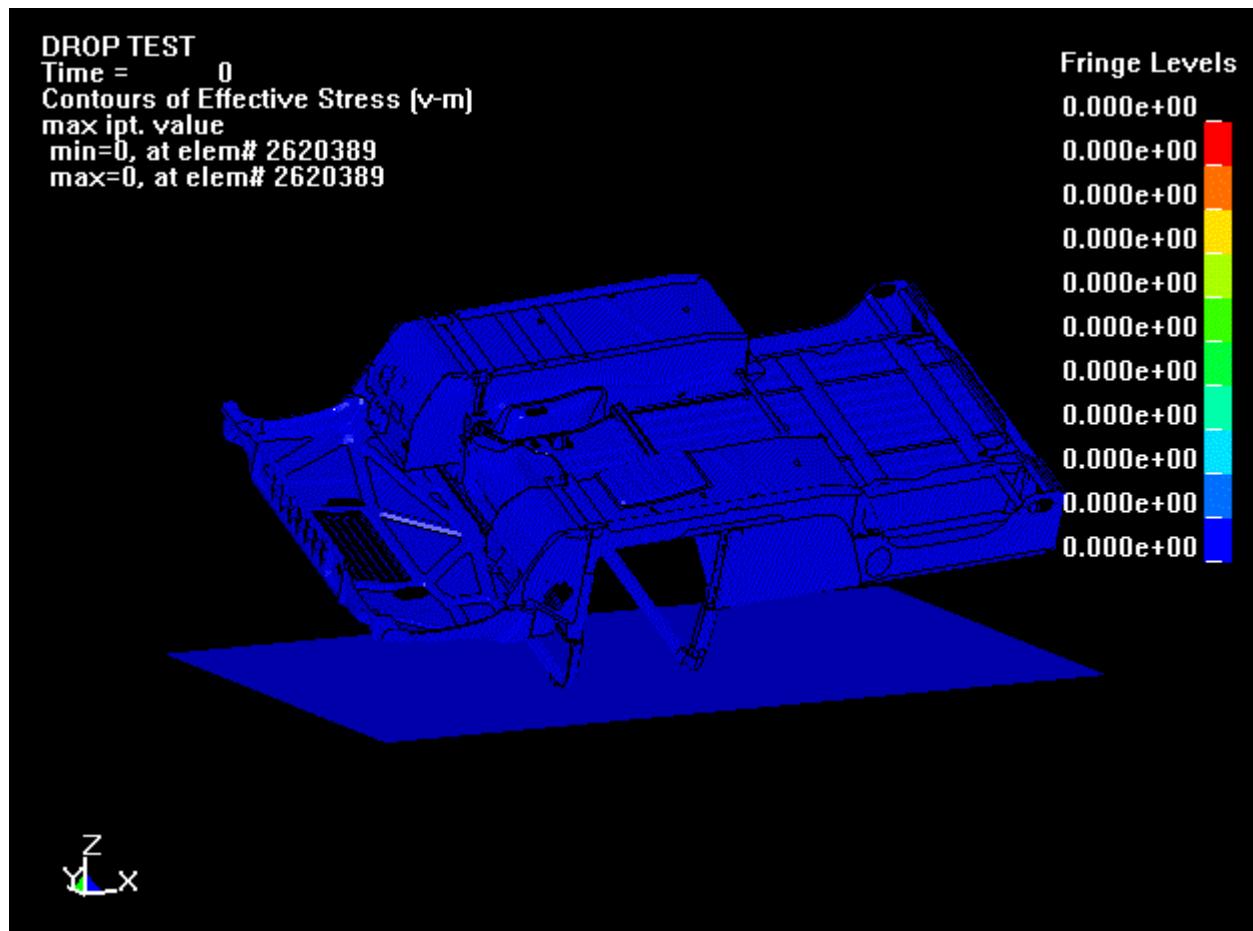


J-Turn Analysis Results

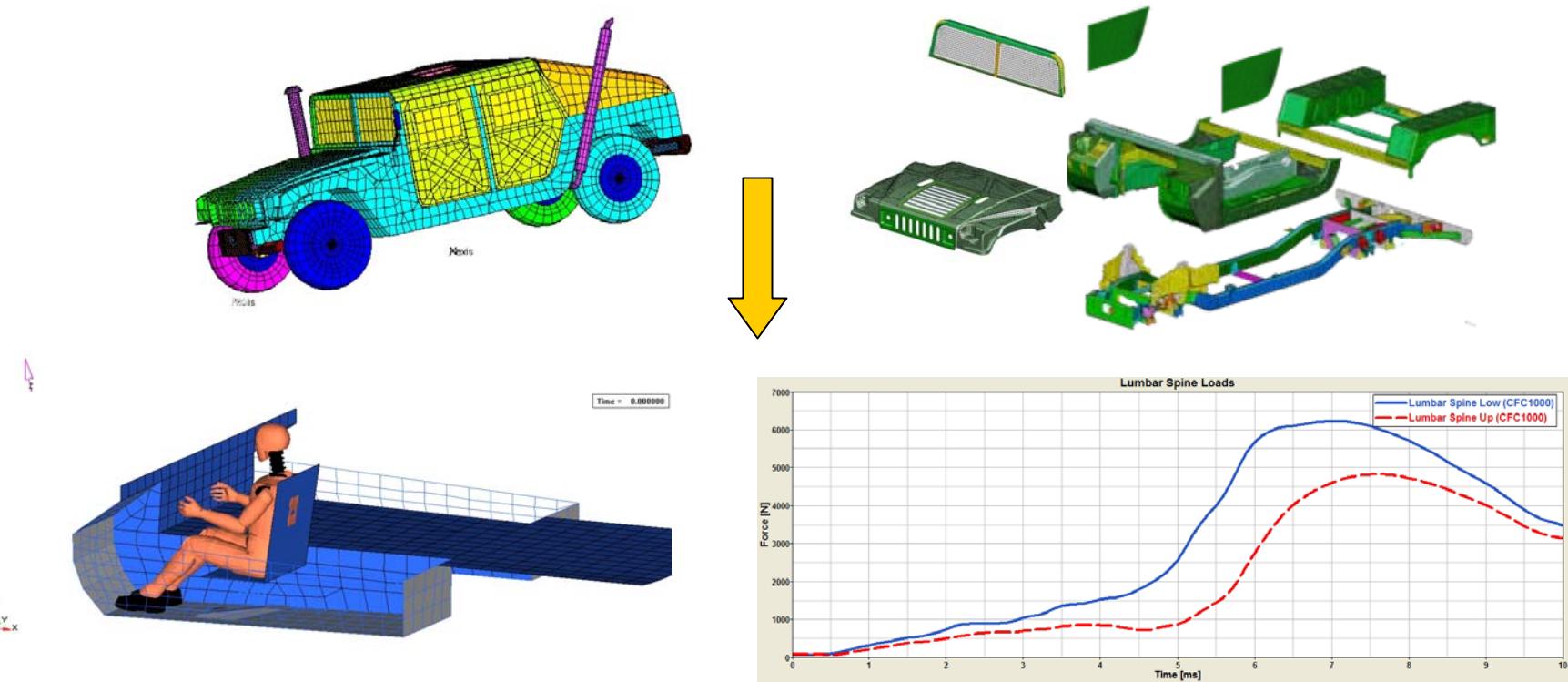


Roof Strength Analysis

➤ Drop Test



Simulating the Response of Structures and Occupants to Blast Loads



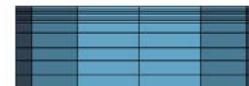
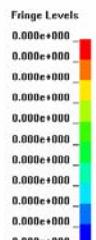
Response of vehicle floor and occupant under blast

J-Turn Rollover under a Blast

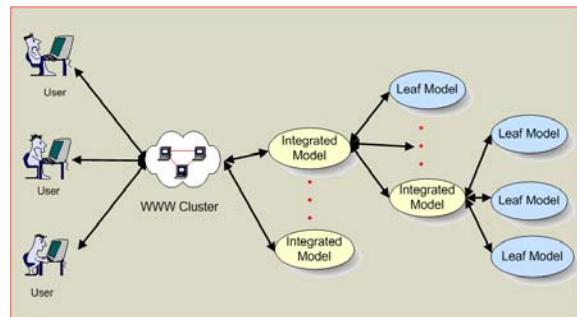
blast2_3 Time= 6.0000 Frame=001



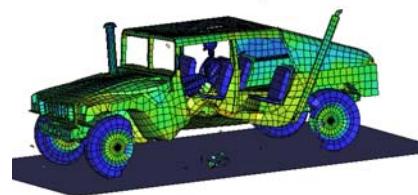
LANDMINE EXPLOSION
Time = 0
Vector of Total velocity
min=0, at node# 58
max=0, at node# 58



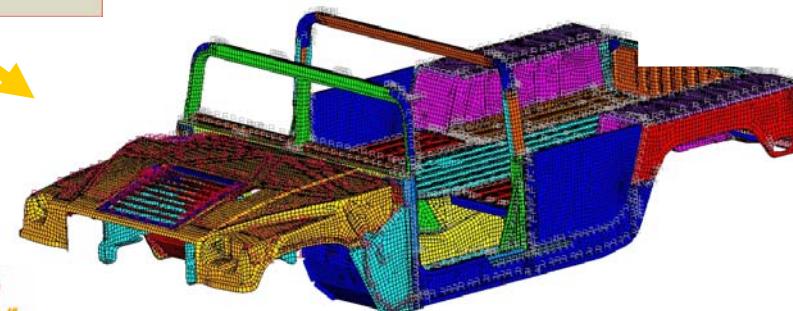
Overview



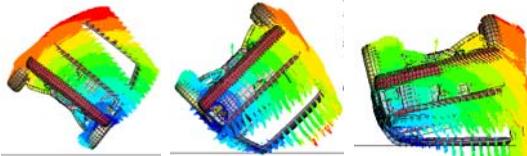
D-Sim



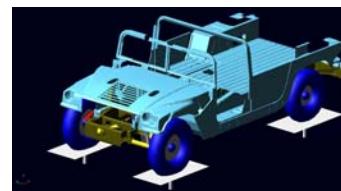
Blast



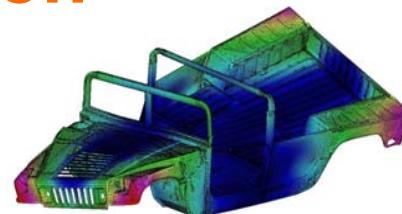
Tire-Terrain Interaction



Crash



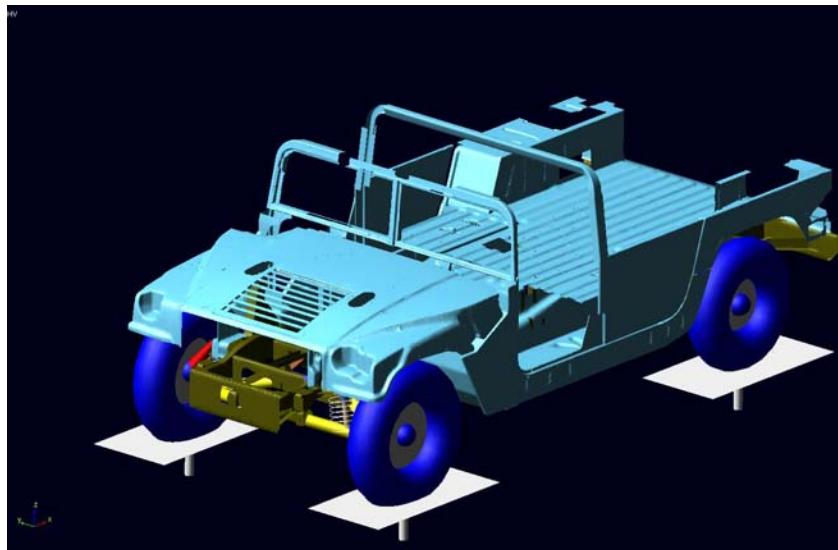
Rollover



Durability



Extreme Terrain



Sand



Ice

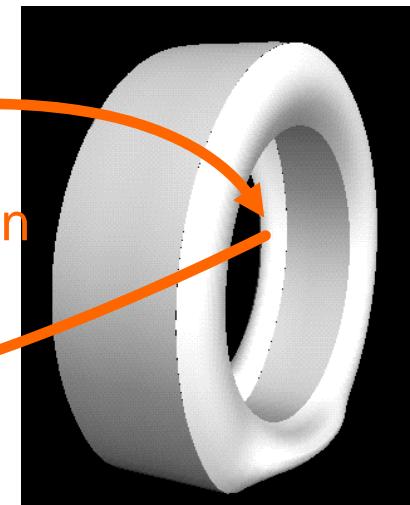
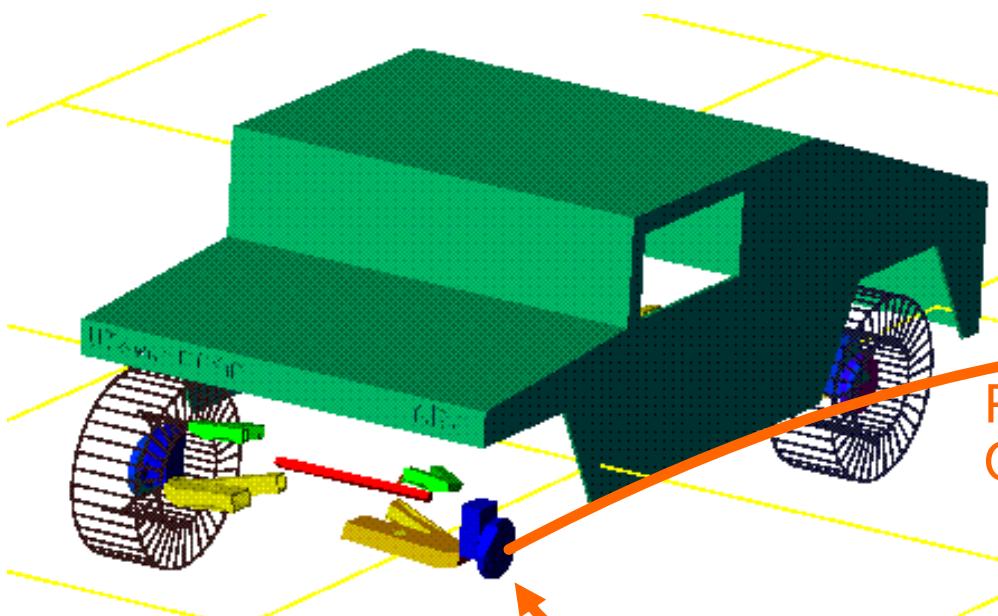


Snow



Tire-Terrain Interaction

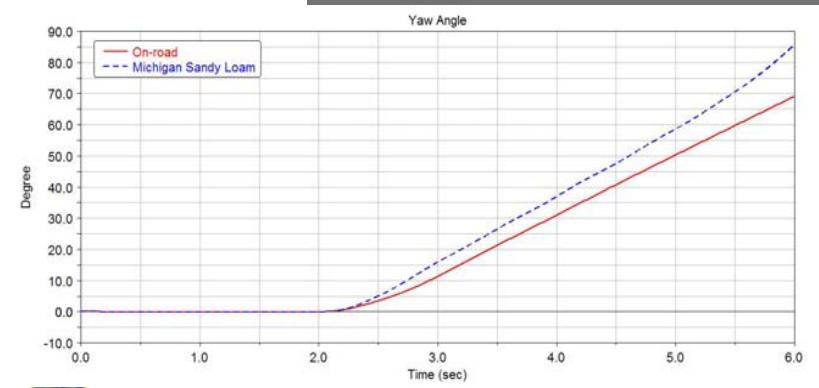
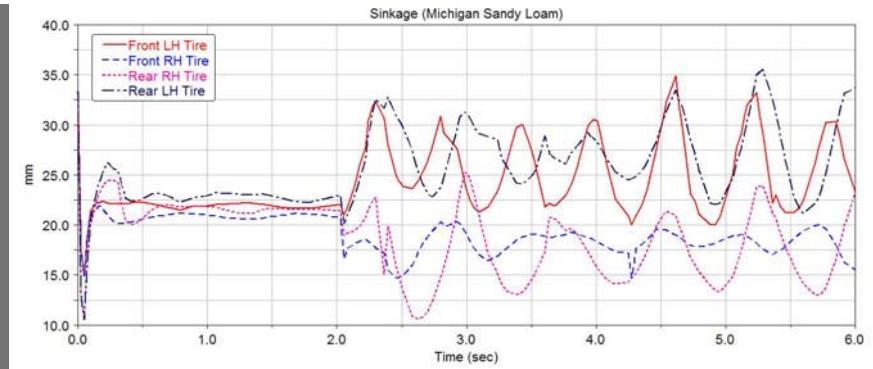
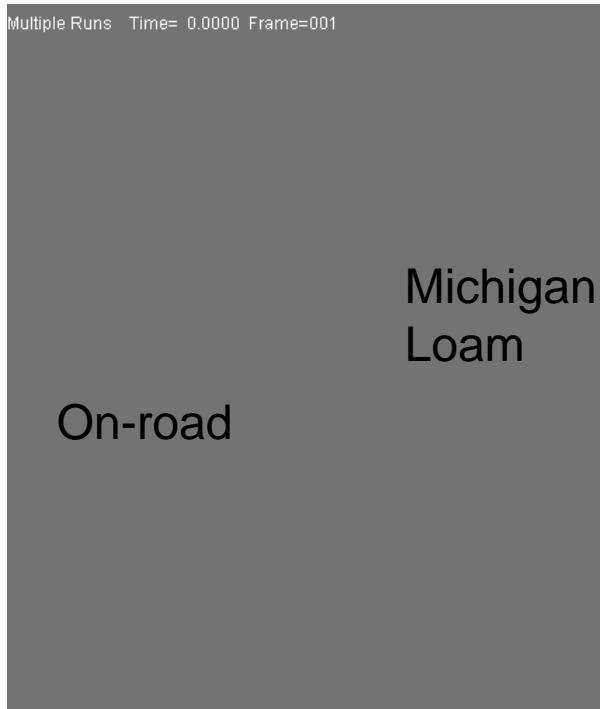
- Tire passes forces / moments to vehicle
- Vehicle passes hub position / orientation to tire



Forces/Moments



Vehicle Performance for Off-Road Events



Summary

- Comprehensive, integrated platform for analysis and design to support current and next generation vehicles
- Enabling technologies:
 - General, functional simulation framework
 - Algorithms for coupling different models and simulation codes
 - Algorithms for coupling non-matching interfaces



Future Developments

- Continue development of model database
- Incorporate human models
 - Driver perception
 - Assess safety systems
- Expand integration with commercial software
- Verify, validate and update model database using instrumented vehicles
- Simulation-based certification

Future Developments

